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EXPERIMENTAL STUDY ON SELF COMPACTING CONCRETE CONTAINS PARTIALLY MANUFACTURED SAND AND RECYCLED CLAY ROOF TILE

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ABSTRACT

Construction is a non-stop process throughout the world due to the population growth with the requirements of their need of structures. The concrete takes a vital role in consumption, strength and quantity wise. The developments in the concrete are vast and continuing. Considerably, the old buildings are demolished and replaced with new concrete buildings. Demolition of buildings are creates waste related problems and environmental issues. From the demolished buildings the wastes can be used for new construction. Self Compacting Concrete (SCC) is suitable for placing in congested reinforcement without vibration and to consolidate under its own weight. The concrete contains major quantity of fine aggregate and coarse aggregate. The depletion of these two materials, the alternative is required to minimise the use of this materials. For the fine aggregates Manufactured sand also known as M-sand can be use partially. For the coarse aggregates, broken clay roof tiles can be use partially. The admixture is also added to gain the property of workability and strength. The concrete grade M20 is considered because, uses widely and in large quantity. The fine and coarse aggregates are replaced by 10%, 20% and 30% each. The basic concrete mix design grade of concrete M20 was arrived as per the Indian Standard Concrete mix proportion-Guidelines IS 10262: 2009. The experiments carried out in fresh concrete are slump flow, T50, V-funnel and T5 minutes, J-ring, L-Box, and U-box tests. For hardened concrete the tests conducted are for compressive strength and split tensile strengths on 7, 14 and 28 days.

Key words: SCC, M-sand, Clay Roof Tile, Fresh Concrete Tests, Hardened Concrete Tests

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1. INTRODUCTION

Self Compacting Concrete (SCC) is a concrete, which flows under its own weight and does not require any external vibration, and known as high performance concrete. The advantages are time required to place reduced, filled uniformly, occupies the congested reinforcement areas, resist segregation, and bleeding, defective workmanship avoided, needs less supervision. This is introduced in the late 1980's by Japanese researcher Professor Okamura and later developed by others in various countries. At present it is widely used all over the world. SCC requires the following properties in its plastic state. Filling Ability is it shall flow into and fill completes all spaces in the formwork and encapsulate reinforcement while maintaining homogeneity. Passing Ability: It must pass through obstacles like narrow sections in form work, closely spaced reinforcement bars without getting blocked by interlocking of aggregate particles. Resistance to segregation: SCC have to capability to retain homogeneity in the distribution of ingredient in fresh state during both static and moving condition i.e., during mixing, transportation and placing.

Generally concrete consists of water, cement, fine and coarse aggregates. Ordinary Portland Cement (OPC) of grade 53 was used as binding material. The objective of this study is to investigate the use of manufactured sand known as M-sand and recycled clay roof tiles in partial replacement of fine and coarse aggregates in the fresh and hardened properties of SCC. Grade of concrete used was M20. The commercially available chemical admixture used in this study is poly-carboxylic based super plasticizer. Natural sand for use as fine aggregate is becoming scarce, environmental effects like ground water level goes down and change of water flow direction. The coarse aggregate also in scarce and production process of it effects the environmental. Due to the depletion of natural sources of these two materials, the alternative is required to minimize the use of these materials to a considerable quantity.

M-sand is produced from crushing of granite stones to be used for construction purposes as a replacement for river sand. M-sand is more superior to the river sand as fine aggregate in mortars and concrete. M-Sand has balanced physical and chemical properties that can withstand any aggressive environmental and climatic conditions as it has enhanced durability, greater strength and overall economy. Usage of M-Sand can overcome the defects occurring in concrete such as honey combing, segregation, bleeding, voids, capillary etc. M-Sand prevents the corrosion of reinforcement steel by reducing permeability, moisture ingress, freeze-thaw effect increasing the durability of concrete structures. The superior shape, proper gradation of fines, smooth surface texture and consistency in production parameter of chemically stable sands provides higher strength to concrete. M-sand of the cubical shape with grounded edge and superior gradation gives good plasticity to mortar providing excellent workability. The control over these physical properties of manufacturing sand make the concrete require less amount of water and provide higher workable concrete. The less use of water also helps in increasing the strength of concrete, less effort for mixing and placement of concrete, and thus increases productivity of construction activities at site.

2. EXPERIMENTAL INVESTIGATION

2.1. MATERIALS

2.1.1. Cement

Ordinary Portland cement Grade53 (OPC53) confirming to IS 12269 – 2013 was used and its physical properties are given in Table 1.

2.1.2. Fine aggregate

Sand: Locally available natural sand with 4.75mm maximum size was used. Its physical properties are given in Table 2 and conformed to IS: 383 – 1970.

M-sand: Available in local market, 4.75mm maximum size. The physical properties are given in Table 2

2.1.3. Coarse aggregate

Crushed stone: Locally available crushed stone with 12.5 maximum size and its physical properties are given in Table 3 and conformed to IS: 383 – 1970.

Clay roof tiles: This is collected from local clay roof tile building demolished to construct new concrete building. The physical properties are given in Table 3

2.1.4. Chemical admixture

Super plasticizer Conplast SP430(G) complies with IS:9103:1999 and BS:5075 Part 3 and ASTM-C-494 Type 'F' as a high range water reducing admixture and Type G at high dosage is used.

2.2.5 Water

Water used was fresh, colorless, odorless and tasteless potable water free from organic matter of any type.

Table 1 Physical properties of cement OPC53

Physical Requirements	Requirement as per IS 12269 : 2013	Results
Fineness Specific Surface (m2/kg)	225(min)	280
Vicat Initial Setting Time (min)	30 (min)	45
Vicat Final Setting Time(min)	600 (max)	240
Soundness By LeChatelier Method (mm)	10 (max)	1
Soundness By Auto Clave (%)	0.8 (max)	0.074
Compressive Strength in 3 days (M Pa)	27 (min)	38
Compressive Strength in 7 days (M Pa)	37 (min)	48
Compressive Strength in 28 days (M Pa)	53 (min)	60
Normal Consistency	28%	29%
Specific gravity	3.15	3.15

Table 2 Physical properties of Fine aggregate

Physical tests	Sand	M-sand
Specific gravity	2.63	2.63
Fineness modulus	4.23	4.66
Bulk density kg/m^3	1540	1540

Table 3 Physical properties of Coarse aggregate

Physical tests	Coarse Aggregate	Clay roof tile
Specific gravity	2.77	2.11
Fineness modulus	5.85	4.3
Bulk density g/m^3	1584	1130

2.2. Mix Proportions

One control and three SCC mixes with different replacements of sand and aggregate with M-sand and clay roof tiles were prepared and examined to quantify the properties of SCC. The replacement was done at levels of 10%, 20% and 30% of sand and aggregates each. The water/powder mass ratio (w/p) was selected as 0.45. The control mix's concrete grade is selected as M20 because, most of the normal building are used this grade in a large quantity. The control mix M20 is designed as per Indian Standard concrete mix proportioning – guidelines (First Revision) IS 10262: 2009. For SCC the same mix is added with super plastiser accordingly water and cement ratio are changed and also sand and aggregate are replaced with M-sand and clay roof tiles. Table 4 presents the composition of control mix and SCC mixtures. The mixes are classified as for normal concrete is NC1, 10%, 20% and 30% replacement of sand and aggregate each with M-sand and clay roof tiles are denoted as SCC1, SCC2 and SCC3 respectively.

Table 4 Mix proportion for concrete

Mix ID	NC1	SCC1	SCC2	SCC3	Unit
Water	197	158	158	158	Kg/m^3
Cement	438	350	350	350	Kg/m^3
Fine aggregate					
Sand	772	762	677	593	Kg/m^3
M-sand	---	85	169	254	Kg/m^3
Coarse aggregate					
Crushed stone	1026	1013	900	788	Kg/m^3
Clay roof tiles	---	102	205	307	Kg/m^3
Super plastiser	---	3.5	3.5	3.5	lt
W/C ratio	0.4	0.4	0.4	0.4	---
W/B ratio	0.45	0.45	0.45	0.45	---
Replacements in %	---	10%	20%	30%	---

3. RESULTS AND DISCUSSIONS

In this study, fresh properties self-compacting concrete were investigated by replacing partially Sand with M-sand and coarse aggregate with recycled clay roof tiles at three replacement rates as 10%, 20% and 30% each. The investigations were carried out according to appropriate criteria given by European standards. In the present study, such properties of self-compacting

concrete produced with partial contain of M-sand and recycled clay roof tiles were investigated based on fresh concrete tests, specifically workability tests.

3.1. Slump flow and T50 tests

The slump value plays a major role in SCC. By the value of slump, it is possible to know the effectiveness of flow in SCC; i.e., flow ability of SCC under congested reinforcements can be studied at site through this test. The slump values also determine the durability of the mix, segregation and bleeding in the mix. The minimum value of slump is to be 650mm and the maximum value 800 mm for a fresh SCC. The slump values and T50 values for different mixes are shown in Table 6 This helps us know the filling ability of SCC.

Table 6 Test results for Slump flow and T50

Mix	Slump flow	T50
NC1	400	----
SCC1	660	4.5
SCC2	690	4.0
SCC3	710	3.5

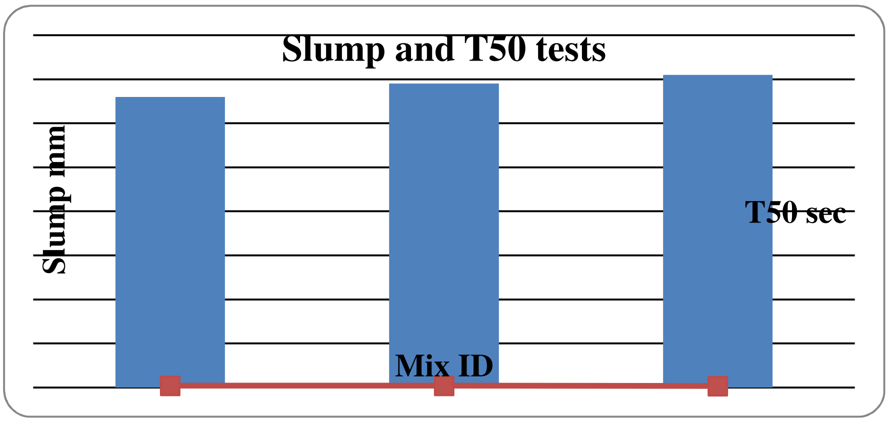

Figure 1 Slump and T50

From slump flow and T50 tests, SCC3 behaves better compared with others.

3.2. J-ring test

J-Ring is an excellent test for the passing ability of SCC. The difference in height between the concrete inside and that just outside the J-ring is measured. This is an indication of passing ability, or the degree to which the passage of concrete through the bars is restricted. In J-ring the minimum value is 0 (zero) and maximum value is 10 mm. The values are shown in Table 7.

Table 7 Test results J-ring

Mix	Inside height (H1) mm	Outside height (H2) mm	Difference (H1-H2) mm
SCC1	19	11	8
SCC2	15	10	5
SCC3	13	10	3

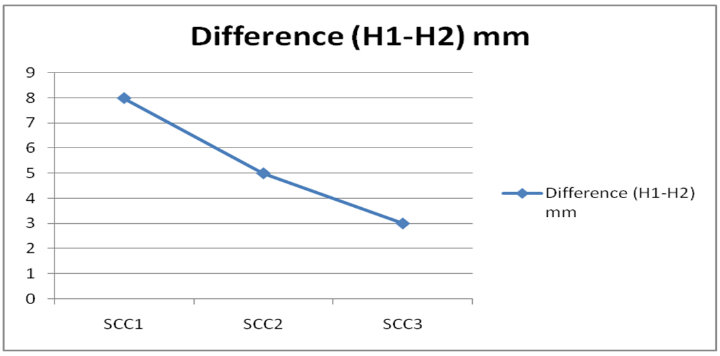

Figure 2 J-ring test

3.3. V-funnel and V-funnel at T5minutes Time increase tests

V-funnel and V-funnel at T5minutes tests are for filling ability and Segregation resistance of SCC. V-funnel is the test for time taken to emptying the container after fill of concrete and rest for 5 seconds. But, for V-funnel at T5 minutes is the concrete left for 5 minutes and start to emptying it. In the both tests the time is observed.

The values are shown in Table 8.

Table 8 Test results V-funnel and V-funnel at T5 minutes

Mix	V-funnel (Sec)	V-funnel at T5minutes (Sec)
SCC1	7	14
SCC2	8	13
SCC3	10	11

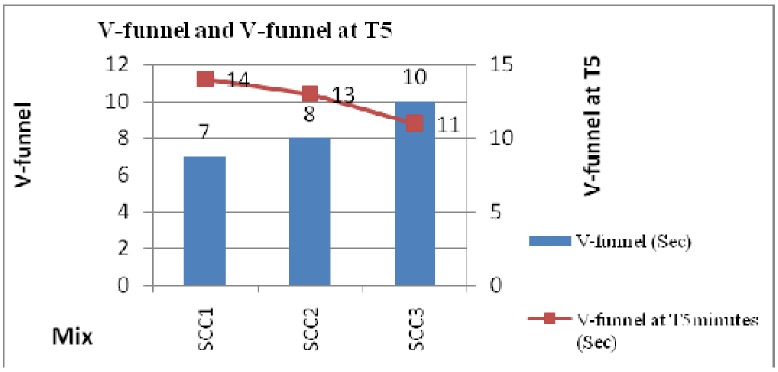

Figure 3 V- funnel test

3.4. L-box tests

The L-box test gives the passing ability of SCC beyond the reinforcing bars. The mix having high powder content and lesser coarse aggregate passes easily through the reinforcing bars. The ratio of H1/H2 is used to indicate the value of the result of L-box. The minimum value of H1/H2 can be 0.8 and the maximum value 1.0. The values are shown in Table 9.

Table 9 Test results L-box T20, T40 and ratio

Mix	T20 (Sec)	T40 (Sec)	Height (H1) mm	Height (H2) mm	Ratio (H2/H1)
SCC1	13	10	145	115	0.79
SCC2	10	8	140	125	0.89
SCC3	7	6	130	120	0.92

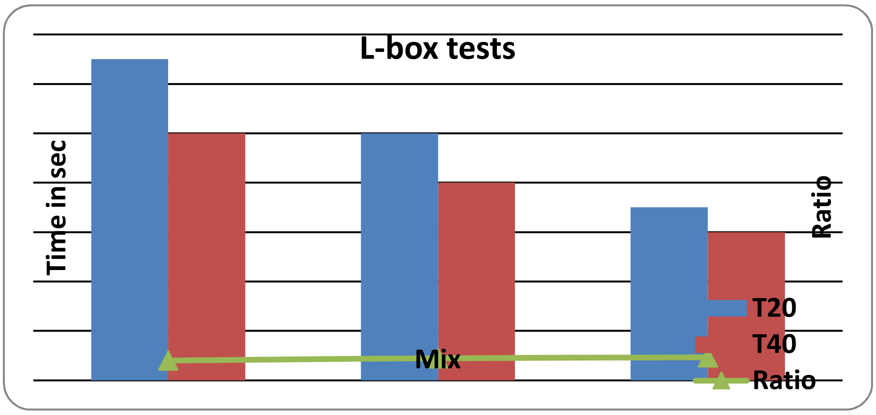

Figure 4 L-box test

3.5. U-box test

U-box test is used to find the passing ability of SCC through the reinforcing bars, similar to that of the L-box test. The limitation of U-box test as specified by EFNARC guidelines is the difference in height H1 and H2 to be within the limit of 0-30 mm. The values are shown in Table 10.

Table 10 Test results U-box

Mix	Height (H1) mm	Height (H2) mm	Difference (H1-H2) mm
SCC1	342	316	26
SCC2	337	321	16
SCC3	331	326	5

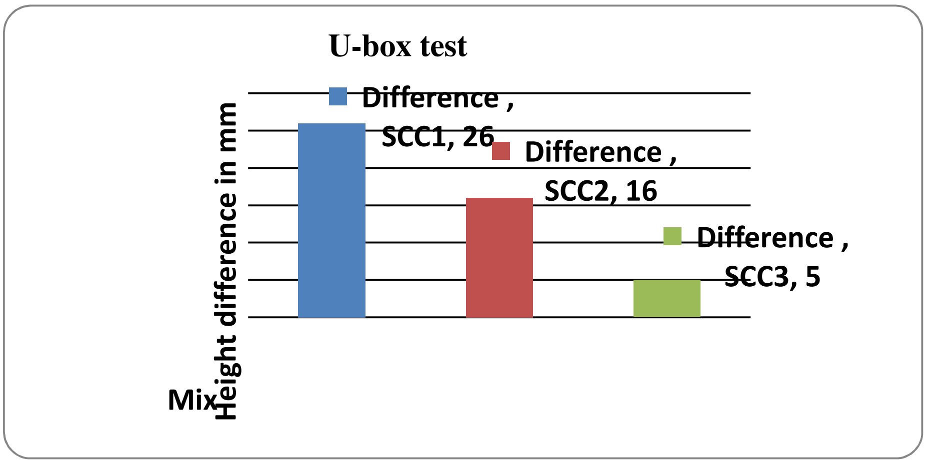

Figure 5 U-box test

3.6. Compressive Strength test

Table 11 Compressive strength Test results

Mix ID	Compressive strength (MPa)		
	7 days	14 days	28 days
NC1	25.24	29.67	34.98
SCC1	10.96	14.93	18.90
SCC2	11.76	15.13	19.07
SCC3	13.17	16.33	21.23

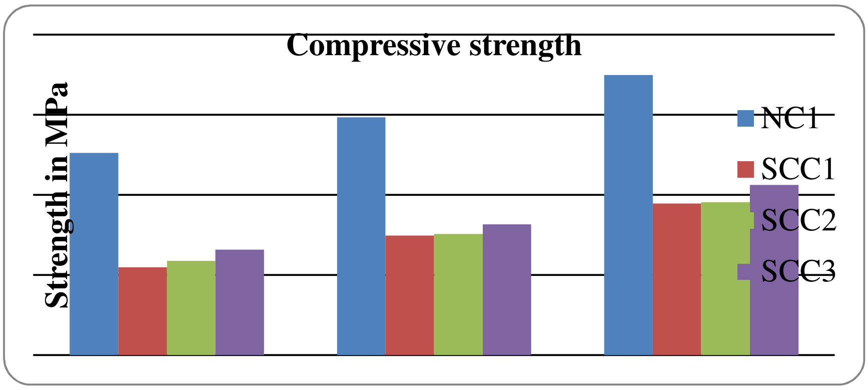

Figure 6 Compressive strength

The compressive strength test result shows the mix SCC3 given good strength on 28 day result. During the period its strength will increase further. The other mixes also in a good strength. The variation is less than 5% to 6% for of 20MPa strength.

3.7. Split tensile strength test

The average of three cylindrical specimens tested on each day results are given in the Table 12.

Table 12 Spilt tensile strength Test results

Mix ID	Spilt tensile strength (MPa)		
	7 days	14 days	28 days
NC1	2.37	3.03	3.63
SCC1	1.86	2.37	2.84
SCC2	2.10	2.79	3.31
SCC3	2.28	3.21	3.54

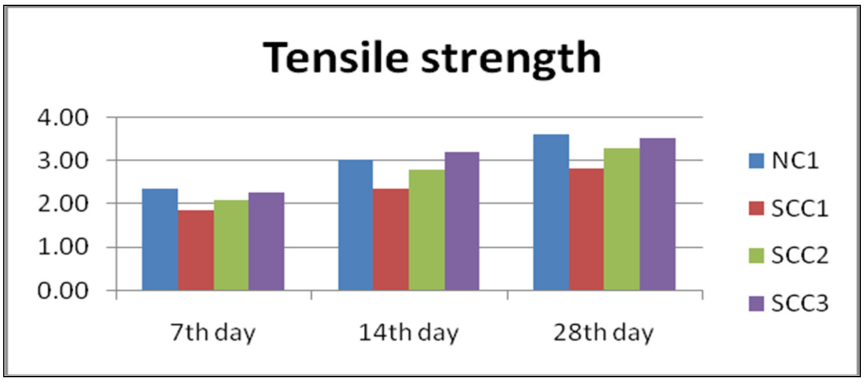

Figure 7 Spilt tensile strength

4. CONCLUSION

Based on the systematic and detailed experimental study conducted on SCC mixes with an aim to develop performance mixes, the following are the conclusions arrived.

1. As per the mix design the cement added to the mix of SCC is comparatively less due to the addition of super plasticiser. The cement is 20% less consumed than the normal concrete. The water consumption for SCC is 20% less than normal concrete due to the addition of super plasticiser.
2. Generally all the three mixes satisfy the property of SCC. Particularly SCC3 gives better results rather than SCC1 and SCC2. The reason is by the addition of super plasticiser and coarse aggregate of granite quantity is less in SCC3.
3. Reducing the coarse aggregate of granite, the workability of concrete performs better.
4. Fresh properties of the SCC were evaluated based on the slump flow, T50, V-funnel and T5, J-ring, L-Box, and U-box tests. Hardened properties of the SCC are evaluated based on Compressive Strength and Split tensile strength tests.
5. By using recycled clay roof tiles as partial replacement of coarse aggregates in concrete, the overall density can be reduced compared to regular concrete.
6. Compressive strength of SCC3 on 28th day test result is slightly higher than the M20 grade concrete strength. Others also have only very less difference. But, during the long period it may also attain the required strength. Tensile strength test is satisfied to the requirement.
7. This investigation is preliminary and future work will address extensive investigations in order to obtain final conclusions and possibilities of application of recycled clay roof tiles as coarse aggregates for concrete. However more elaborated work is required with different mix ratios and different percentages of used bricks for better conclusions.
8. It is shown that a good SCC could be obtained using appropriate materials contents.
9. Although results obtained from all of the mixes satisfy the lower and upper limits suggested by EFNARC (The European Federation of Specialist Construction Chemicals and Concrete Systems), all mixes had good flow ability and possessed self-compaction characteristics.

REFERENCES

[1] A.A. Maghsoudi, Sh. Mohamadpour, M. Maghsoudi, Mix design and mechanical properties of self compacting light weight concrete, 9(3), September 2011, pp. 230-236, International Journal of Civil Engineering.

[2] Abderahmane Seddik, Ahmed Beroual, Abdesselam Zergua, Mohamed Nacer Guetteche, Self Compacting Concrete under Local Conditions, Open Journal of Civil Engineering, 2013, 3, pp. 119-125, June 2013 (http://www.scirp.org/ journal/ojce)

[3] B.H.V. Pai, M. Nandy, A. Krishnamoorthy, P.K.Sarkar, C. Pramukh Ganapathy, Experimental study on self compacting concrete containing industrial by-products European Scientific Journal April 2014 edition 10(12) pp. 292-300

[4] EFNARC. (2005). The European guidelines for self-compacting concrete: specification, production and use. www.efnarc.org

[5] Gopi Rajamanickam, Revathi Vaiyapuri, Self compacting self curing concrete with lightweight aggregates, GRAĐEVINAR 68 (2016) 4, pp. 279-285, Građevinar 4/2016

[6] Her-Yung Wang, Yi-Fang Shih and Hen-Ching Su "A Study on of the Engineering Properties of Self-Compacting Mass Concrete" (SCMC) Volume 4, Issue 3, pp. 1-6, 2015, Research Article, Architectural Engineering Technology Department of Civil Engineering, National Kaohsiung University of Applied Sciences, 807, Taiwan.

[7] I. Ajay Kumar, "Effect of Size of Aggregate on High Strength Self Compacting Concrete" (2015) International Journal of Science and Research (IJSR), pp. 1956-1958.

[8] IS: 10262-2009, Recommended guidelines for concrete mix design, Indian standards bureau, New Delhi, India.

[9] IS: 383 (Specification for coarse and fine aggregates from natural sources for concrete), Indian Standard Code of Practice, 1970.

[10] IS: 456-2000, Plain and reinforced concrete code of practice, Indian standards bureau, New Delhi, India.

[11] Mallesh.M, Sharanabasava, Reena.K, Madhukaran, Experimental Studies on M25 Grade of Self Compacting Concrete" Volume: 02 Issue: 06, Sep -2015, pp. 1004-1008, International Research Journal of Engineering and Technology (IRJET), www.irjet.net.

[12] Martins Pilegis, Diane Gardner and Robert Lark, "An Investigation into the Use of Manufactured Sand as a 100% Replacement for Fine Aggregate in Concrete" Article, Materials 2016, 9, 440, pp. 1-19, www.mdpi.com/journal/ materials

[13] Okamura, H. and Ouchi, M. "Self-compacting concrete, development, present use and future". Proceedings of the 1st International RILEM Symposium on Self-Compacting Concrete, pp. 3-14. 1999, Stockholm, Sweden.

[14] Oladipupo S. Olafusi, Adekunle P. Adewuyi, Abiodun I. Otunla, Adewale O. Babalola, "Evaluation of Fresh and Hardened Properties of Self-Compacting Concrete", Open Journal of Civil Engineering, 2015, 5, pp. 1-7, www.scirp.org/ journal/ojce

[15] Ordinary Portland cement Grade53 (OPC53) confirming to IS 12269 – 2013.

[16] Payal Painuly, Itika Uniyal, "literature review on self-compacting concrete" Volume 4, Issue 2 (March-April, 2016), pp. 178-180, International Journal of Technical Research and Applications, www.ijtra.com.

[17] Prof. Balasaheb E. Gite1, Prof. Madhuri K. Rathi, Prof. Avinash V. Navale "Appraisal of Strength of Self Compacted Concrete with Variable Size of Steel Fibre" International Journal of Innovative Research in Science, Engineering and Technology Vol. 3, Issue 11, pp. 17351-17358, November 2014, www.ijirset.com.

[18] Qahir N. S. AL-Kadi1, Arabi N. S. AL Qadi, Kamal Nasharuddin Bin Mustapha, Sivakumar Naganathan, Zakaria Bin Che Muda, "Coconut Fibre Effect on Fresh and Thermo Gravimetric Properties to Mitigate Spalling of Self-Compacting Concrete at Elevated Temperatures" Open Journal of Civil Engineering, 2015, 5, pp. 328-338, http://www.scirp.org/journal/ojce

[19] Reena K, Mallesh M, "experimental studies on M20 self compacting concrete, Volume No.02, Issue No. 09, September 2014 International Journal of Advanced Technology in Engineering and Science www.ijates.com

[20] Riaz Bhanbhro, Irfanullah Memon, Aziz Ansari, Ahsan Shah, Bashir Ahmed Memon, "Properties Evaluation of Concrete Using Local Used Bricks as Coarse Aggregate Engineering" 2014, 6, pp. 211-216 http://www.scirp.org/journal/eng

[21] S.M.Dumme, Effect of Super plastisicer on Fresh and Hardened Properties of Self-Compacting Concrete Containing Fly Ash, Volume-03, Issue-03, 2014, pp. 205-211, American Journal of Engineering Research (AJER), www.ajer.org.

[22] S.SeshaPhani, Dr.Seshadri Sekhar, Dr.Srinivasa Rao, Dr.Saravana, Evaluation of Relationship between Mechanical Properties of High Strength Self Compacting Concrete, Volume-02, Issue-04, 2013, pp. 67-71, American Journal of Engineering Research (AJER), www.ajer.org.

[23] Y. Vanhove and C. Djelal, Friction Mechanisms of Fresh Concrete Under Pressure, International Journal of Civil Engineering and Technology (IJCIET), Volume 4, Issue 6, November – December, pp. 67-81.

[24] Yasser Sharifi, Iman Afshoon, Zeinab Firoozjaei, and Amin Momeni, Utilization of Waste Glass Micro-particles in Producing Self-Consolidating Concrete Mixtures, International Journal of Concrete Structures and Materials, Vol.10, No.3, pp. 337–353, September 2016.